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THE SANITARY CONSTRUCTION AND EQUIPMENT OF ABATTOIRS AND PACKING HOUSES.

BY

G. H. PARKS,
Architect, Bureau of Animal Industry.

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CONTENTS.

ILLUSTRATIONS.

THE SANITARY CONSTRUCTION AND EQUIPMENT OF ABATTOIRS AND PACKING HOUSES.

By G. H. Parks,
Architect, Bureau of Animal Industry.

INTRODUCTION.

In this country previous to the last three or four years but little attention had been given to the sanitary character of the buildings designed for abattoirs, packing houses, and rendering plants, the dominating idea being to arrange and construct the buildings so that the products from the establishments could be finished and delivered with the least outlay of capital. The result generally has been that the principal laws of hygiene have been violated, unless it was found that the market value of the products decreased because of the insanitary conditions in which they were produced. The violation of the hygienic laws was, perhaps, due in part to the lack of knowledge of such laws and to a failure to appreciate properly the possible harmful results which might be caused to the community at large through the consumption of food products produced under insanitary conditions.

Prior to the passage of the meat-inspection law of 1906 the United States Department of Agriculture had no legal power to enforce sanitation at slaughtering and packing establishments. By that law, however, the Department was given such authority, and it now requires that such establishments shall be maintained in a sanitary condition, and great improvement has resulted. Sanitary principles have been applied in the construction of new buildings, and many old buildings have been practically reconstructed. In some old buildings it is difficult and expensive to secure and maintain cleanliness, and the total elimination of insanitary features has sometimes been found impossible; yet certain definite and decided improvements have been made, and a reasonably satisfactory state of sanitation is required as a prerequisite to doing business under federal inspection. As these older buildings are gradually replaced by new structures it will be possible to incorporate the best features of modern sanitary construction and thus obviate the difficulty of keeping buildings clean that were erected without regard to that object. The greatest need for sanitary reform is found in local establishments operating without inspection.

PRIME NECESSITY OF CLEANLINESS.

The first condition requisite in an abattoir or packing house is cleanliness throughout the establishment. Cleanliness signifies the absence of dirt, and dirt is defined as matter out of place. Odors are matter, and undesirable and noxious odors caused by decaying products should be removed, not alone by the aid of exhaust fans and natural ventilation, but by the elimination of dirt. It will not be practicable to maintain the degree of cleanliness required in an operating room of a hospital, but it is practicable and requisite that a high standard of cleanliness be maintained. A high standard can not be attained without proper construction and planning of the various departments of the buildings and of the equipment.

PRINCIPAL SANITARY FEATURES IN ABATTOIR CONSTRUCTION.

The term "sanitary" means that which is conducive to the preservation of health, and "sanitary construction" means such construction as will eliminate those factors of construction that tend to make the buildings insanitary.

The features which are principally at fault in abattoirs may be summarized as follows: Location, plan, material, and construction of the buildings, lack of sunlight, ventilation, plumbing and drainage, materials and construction of the equipment, and water.

All buildings that are to be used for the purpose of slaughtering animals for the preparation of meat or meat food products should meet the following requirements:

1. A location on a site that is dry and with an aspect which gives an abundance of sunlight.
2. An abundant supply of pure water, by means of which perfect cleanliness of all parts of the building can be secured, and proper means for the removal of waste water.
3. A system of immediate and perfect sewage removal which renders it impossible that the air or water shall be contaminated.
4. A system of ventilation which carries off all impurities from the air of the rooms and supplies clean, pure air as required.
5. A condition of building construction which admits of perfect cleanliness of the ceilings, columns, walls, and floors.
6. Proper equipment.

LOCATION.

A large number of the present establishments have been located that direct connection may be had with the railroads, and as it is the custom for railroads to be on low grades, the establishments are in many instances situated on the banks of rivers. Such lands are almost always badly drained and are subject to overflow when the

rivers are flooded. The water backs up in the sewers and prevents proper drainage. When the sewers back up recourse is had to pumps, but the results are not satisfactory. The cellars where meats are stored become flooded, and after the subsidence of the water the walls and floors are covered with a deposit of sediment which renders the rooms, until cleaned, totally unfit for use for the storage or handling of meats. During the flooded condition of the cellars much of the meat is damaged, and this entails great loss, not alone to the producer, but also to the consumer.

There are other establishments so located that the surrounding premises are undrained and pools of stagnant water are seen on the surface of the ground.

Some few of the smaller factories have been found in rooms in the basements of dwelling houses. Generally in cases of this character the entire surroundings are in an undesirable condition, caused by the accumulation of refuse in the alleys, back yards, and courts. The windows of the basement generally open on the level of the ground outside or into areas closed with gratings, but there is usually to be found an accumulation of filth in the area, so that the air admitted to the rooms is not wholesome. Establishments of this character are to be found in the congested portions of cities, and as the alleys are under the control of the city authorities, the owners of the establishments depend entirely upon the officers of the health department to keep the alleys clean. This cleaning is usually done spasmodically and with very indifferent success.

Buildings with outside openings into alleys, back yards, or courts that are not kept clean should never be used for the preparation of meat or meat food products. It is imperative that no buildings where meat or meat food products are prepared or stored shall have any openings that will admit the outside air from surroundings that are not or can not be kept in a sanitary condition. An exception to this might be allowed if the establishment is furnished with a proper equipment to purify all the air admitted to the building and where the cleaned air is forced into the various rooms.

NATURAL LIGHT.

Sunlight in abundance should be admitted to all rooms where meat or meat food products are prepared, with the exception, perhaps, of the dry-salt and pickle cellars, oleo seeding rooms, and chill rooms. The admission of much sunlight to dry-salt cellars is objected to by some meat packers, as it is claimed that the light darkens the meat, but there are others who hold that the light is not objectionable in this respect. It is a fact, however, that much glass surface in the walls of chilled rooms does influence the refrigeration. There is

apparently less need for direct sunlight in the dry-salt cellars than in any of the other rooms, for the floors are generally kept sterile to a degree by the salt and brine, and the temperature of the rooms is comparatively low. In all rooms where the normal temperature is relatively high it is imperative, from a sanitary standpoint, that sufficient windows and sash be supplied, so that the sunlight can penetrate the entire depth of the room and that practically the entire floor will have been covered during the day. This sunlight should be direct and not diffused light, such as comes through the wire glass generally employed for fire protection. The action of sunlight as a disinfectant or sterilizing agent is much diminished when the light is diffused. The windows in the outside walls should be numerous and should not have the sills more than 5 feet from the floor, and the tops of the windows should be as near the ceilings as practicable. The higher the tops of the windows are from the floor the farther the sunlight will penetrate the room. In rooms over 60 feet in width monitors or skylights are necessary, and these should be placed to run north and south.

WATER SUPPLY.

One of the principal requirements of a slaughterhouse is an abundant supply of both cold and hot water, and particular attention should be paid to the source from which the water is obtained in order that it may be pure. The supply may be obtained from driven wells, shallow wells, rivers, lakes, or if near a city from the water mains of the city.

Where water is required for washing, flushing, or use in the preparation of meat food products, all rooms should be supplied with a complete system of piping for hot and cold water, in order that either kind may be drawn as required.

ARRANGEMENT OF ROOMS AND COMPARTMENTS.

The rooms and compartments should be so constructed and located that the odors of one compartment or room will not penetrate the adjoining rooms. The rooms should be so planned that it will not be necessary to truck or convey any of the nonedible products of the carcasses through or into those rooms or compartments where edible meat products are handled, prepared, or stored; and it is also of importance that edible meat products shall not be conveyed through or stored in rooms that contain the inedible products of the carcasses.

IMPERVIOUS MATERIALS NECESSARY.

The materials used in the construction of the various rooms or compartments should be, as far as practicable, of an impervious character. The impression is erroneous that if a substance is fire resistant it is,

because of this quality, impervious to air and water. Concrete, cement, and plaster are considered by some as presenting a sanitary surface, but this is far from being a fact unless some method is adopted to make them impervious. Concrete and cement plaster are rendered much less porous by an admixture of waterproofing compound, and the surfaces of these materials may be made practically impervious by covering with oil paints or similar substances. Wood, unless painted with oil paint, is not impervious, and the same is true of bricks unless they are painted or have an enameled surface. When the walls and posts of a room are of wood it becomes necessary to use a covering of metal. This metal covering need be but of such a height from the floor as to protect the walls and posts from injury. Above the metal wainscot the woodwork should be painted, preferably with an oil paint, and the surface of the wood should be dressed before the paint is applied.

If the walls are of common brick or terra-cotta blocks the joints should be filled to the face of the bricks or the blocks. The terra-cotta blocks should be covered with hard or cement plaster and troweled down to a smooth surface and then painted with oil paint. The brick walls should also be painted with oil paint. At least three coats of oil paint should be used on all plaster, cement, or brick surfaces. Stone walls should be pargeted with cement mortar to a true surface, and, if other than dry-salt or pickle cellars, should be painted with oil paint.

PAINT.

As all exposed surfaces of the compartments are required to be painted it is advisable to select such paints as are best suited to the character of the rooms. If there is much moisture in the rooms the paint must be nonabsorbent. This quality is possessed by those paints containing oil and by some of the varnishes, such as "spar varnish." Oil paints may be made from white lead or from white zinc and oil with the addition of coloring pigments.

In painting concrete surfaces, cover the surface to be painted with a solution of equal parts by weight of zinc sulphate (white vitriol) and water, applied with an ordinary bristle brush after the cement is dry. Allow from forty-eight to seventy-two hours for the solution to dry after it has been applied to the walls before applying the lead and oil paint finish.

In rooms containing much hydrogen sulphid, if it is desired to paint in light colors, it will be necessary to use pure white zinc and oil, because the white lead turns dark when acted upon by the hydrogen sulphid.

Cold or hot water paints may be used in compartments that are very dry, as paints of this character have but little resistance to moisture.

In selecting colors it is commendable to select those that will aid in the effort to keep the rooms clean, as the paint is not used to cover up the dirt, but to assist in maintaining cleanliness.

Metal work is well protected from rust when the paint used is oil paint, enamel paint, or aluminum paint. Aluminum paint, enamel paint, and elastic varnish are satisfactory for use on pipes subject to great fluctuation of temperature.

CEILINGS.

All ceilings should be so constructed as to present a flat surface. If wood joists are used, the bottoms of the joists should be covered with plain sheets of metal, or planed tongued-and-grooved flooring boards or with plastering. The use of beaded boards is not to be recommended. All ceilings of wood or plaster should be painted with oil paint. The oil paint may be either of lead and oil or zinc and oil. Metal ceilings should be plain and not stamped or embossed, as the smoother the ceilings the more readily they can be kept clean. In ceilings constructed on the mill principle the supporting floor beams and the under side of the floor planks should be planed and all surfaces painted with oil paint.

FLOORS.

There are two points to be considered in the construction of the floors. The first point is that the floors shall be of a nonabsorbent material. This is especially important where during the time of operation there is a continual flow of water on the floors.

The second consideration is to drain the floors properly. Asphalt of the proper degree of hardness to suit the various temperatures of the compartments is probably the best flooring material in use at the present time. When a floor, such as the basement floor, can be constructed on a solid foundation, concrete may be used. The disadvantage of a cement floor is principally that the wearing surface soon wears out under continuous trucking, and as the tensile strength of concrete is not great the floor soon cracks. This is especially true where concrete and cement are overlaid on a wooden floor. The shrinkage of the wood will cause the concrete to settle and crack. The cracks can not be filled with cement with the assurance that the floor will be water-tight. Asphalt has been used to patch concrete and cement floors, and under favorable conditions the results have been satisfactory. The wearing surface of a concrete floor is much improved when a granolithic or granitoid surface is used.

The granolithic and granitoid surfaces are composed of hydraulic cement, crushed stone, sand, and gravel, with the addition of some indurating mineral substance, as baryta or litharge. When properly made and put down they give general satisfaction. They are generally manufactured under a patent.

The common practice of finishing a concrete floor is to add an inch of a mixture consisting of Portland cement 1 part, sand 1 or 2 parts. A particularly good cement will take 1 part of sand, but a poorer quality requires a greater proportion. From improper or faulty mixing of the parts and finishing or troweling down at the wrong stage of the set of the cement, the surface fails in wearing qualities. The practice of adding cement to the surface to temper the mortar ruins the finish, and consequently where the best results are to be obtained this practice should not be allowed.

Owing to the low temperature of the pickle or dry-salt cellar, the concrete and the cement or other finish must be given sufficient time to set and harden thoroughly before the floor is used. Cement sets much more slowly in a low temperature than when the temperature is high.

Floors of brick are not to be recommended, as they are not sanitary even under the best conditions. The brick is too absorbent and the floors are uneven with numerous joints. The bricks are uneven in hardness of burning and require frequent replacing.

Wooden floors to be satisfactory should be made of good material and constructed so as to be water-tight. Alternate wetting and drying will cause decay. Trucking also wears the floor into splinters and prevents it from being thoroughly cleaned. The splintering of the wood can be partially prevented by selecting the rift-sawn or edge-grain flooring. Because of the short life, liability to splinter, and the difficulty of cleaning when splintered, flat or slash-grained wood should not be used.

USE OF ASPHALT FOR FLOORING.

The most important point in asphalt concrete is a good matrix, one that will not soften in the heat of the room or become brittle in the chilled atmosphere of the cold rooms. The aggregate should be as dense as possible, thoroughly coated with the matrix while hot, and closely compacted while cooling. The amount of the matrix should be just sufficient to fill the voids in the aggregate. Many floors of asphalt are unsatisfactory because too much of the matrix was used or because of poor quality, and also because the floors were put down by labor unskilled in the use of asphalt.

Asphalt for surface may be overlaid on a subbase of wood flooring in place of cement aggregate. The wood underfloor must be thoroughly dry and clean. The wood floor is first covered with a layer of waterproof building paper with overlapping joints. The paper is then covered with a coating of asphalt about one-half inch thick. This asphalt is made of mastic, flux, and sand. Next the one-half inch covering is covered by a coat of asphalt 1 inch thick of the same constituents as the first coat. On the top coat is sprinkled dry Portland cement, and the whole surface is troweled, rammed, or rolled

to a true even surface. The life of the floor depends to a great extent on the evenness with which the floor is laid. Water will rot the surface if allowed to stand on it. Trucking will also wear out an asphalt floor if the floor is uneven.

Floors of cement or asphalt should be made with a pitch or fall of not less than one-fourth inch to the foot. This will allow for a little unevenness, consequent to imperfect workmanship.

At the junction of floors and walls the asphalt should be coved and carried up the face of the walls to a sufficient height to prevent the water from running down to the floor below.

FLOOR GUTTERS.

In cement or asphalt floors the gutters should be of metal or formed in the concrete or asphalt. The use of wood is unsatisfactory, as the wood soon decays and it is impossible to make a permanent watertight joint between wood and cement or asphalt.

TOILET AND DRESSING ROOMS.

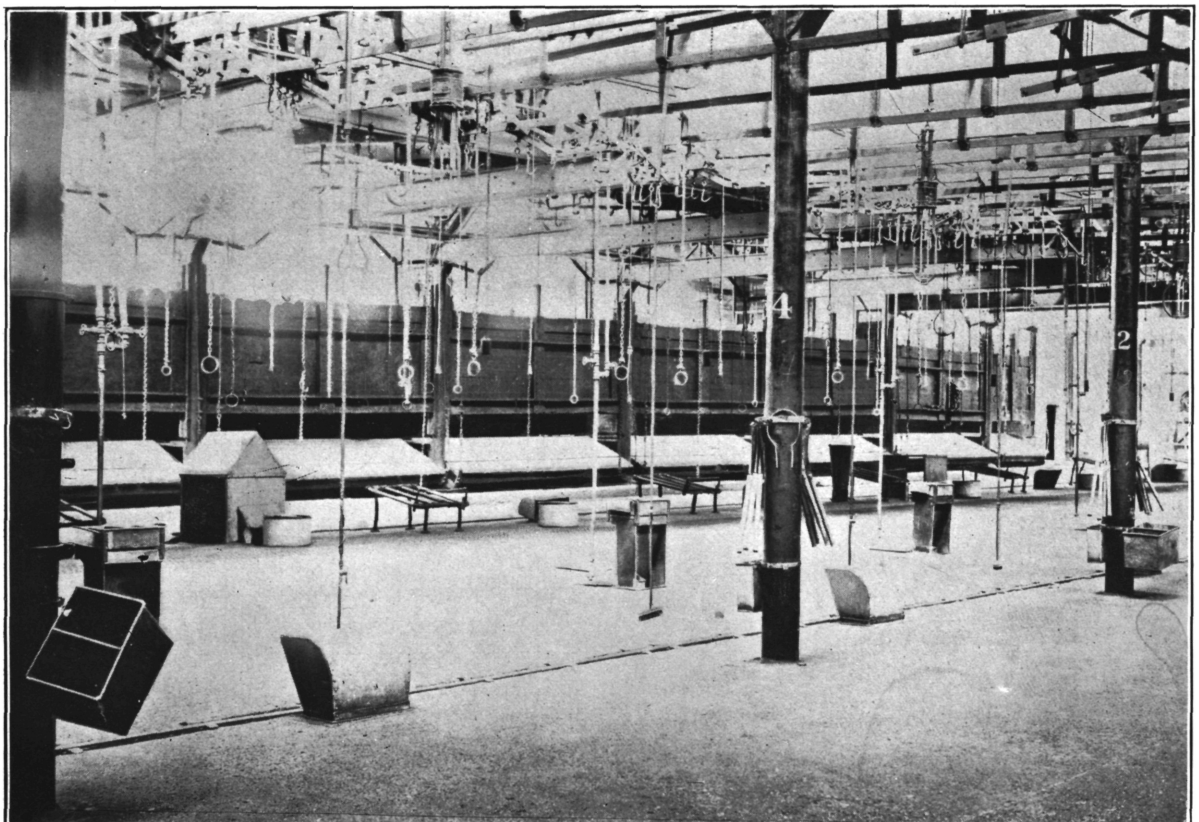
Toilet rooms should be conveniently located, ample in size, and adequate in number. The fixtures should be simple in character and of such material as to be readily kept clean. There must be an ample water supply to flush the closets and urinals thoroughly. Automatic fixtures are to be preferred.

The rooms should be well lighted by an abundance of properly placed windows, and the light should be direct sunlight. The rooms should be thoroughly ventilated. When there is danger of the water freezing in the fixtures it will be advisable to install a system of mechanical ventilation in addition to the natural system.

The floors, walls, and ceilings should be of sanitary construction and material. The floor must be properly drained to facilitate cleaning. All walls and ceilings should be thoroughly painted with oil or other waterproof paint.

The rooms for holding the wearing apparel of the employees should be well lighted by natural light and should be thoroughly ventilated. When necessary the rooms should be thoroughly fumigated and sterilized. It is well to fumigate and sterilize both the working clothes and the street dress.

When lockers are used, separate compartments should be provided for the working clothes and the street clothes. There is a possibility that the street clothes worn to the establishment will bring infection to the dressing room, and if both the working clothes and street clothes are hung in the same compartment in the locker there is a chance for infection and spread of disease. Lockers made of metal are best, and should be so constructed that the compartments are thoroughly ventilated.



INTERIOR OF ABATTOIR WITH SANITARY CONSTRUCTION AND EQUIPMENT.

The system of ventilation of the rooms should be of such a nature as to maintain an even temperature at all times, and should be so arranged that it can not be tampered with by those who are not immediately in charge. When the rooms are ventilated only by means of open windows or sash, the employees will close the windows or sash if the temperature of the room is too cold. The room then ceases to be ventilated, and the air and the garments become saturated with foul odors so that the primary object, that of keeping the clothes sanitary, is defeated.

There are various styles of closets that are satisfactory. Where there are but few employees the separate closet of standard manufacture is acceptable. For the men's toilet room not less than one closet to each 25 men is required. For the women's toilet room not less than one closet to each 20 women is required. Where there is a large number of employees to use one toilet room the best pattern of the range closet is satisfactory. There should be a partition between each two seats or spaces. The range closet with a front rail of hard wood is better than the closet with individual seats, as it is more easily kept in condition both as regards repairs and cleanliness. The closet should have a good depth of water in the trough and an ample flushing service. When closets of this kind are used, the urinal should be omitted in the toilet room, as it is desirable to eliminate all unnecessary urinals on account of the odor arising therefrom. Where the toilet room is far removed from the working rooms it is advisable that a urinal station be installed closer to the working room in order that the employees will not find it necessary to use sheep or cattle pens or dark corners. The ventilation of these rooms must be particularly efficient.

Wash basins or sinks should be adjacent to the toilet and urinal stations, in order that the employees may wash their hands after using the station.

PLUMBING AND DRAINAGE.

All floors must be properly drained by the use of gutters or other effective means to remove from the floors the waste water incident to the processes of preparing the products and from cleaning and washing the rooms and equipment. The proper pitch of the floors to the gutters should be not less than one-fourth inch to the foot, and the gutters should not have less pitch than the floors. The gutters should be trapped into the drainpipes or down spouts by proper water-sealed traps. The "bell" trap is efficient when given proper attention, but as it requires constant attention other traps may be used more advantageously. The removal of the bell from the under side of the strainer entirely defeats the purpose for which the trap is made. Where the bell trap is in use it is not unusual to find the entire top

removed so that in effect no trap at all is supplied. Because of the ease with which this trap is made inefficient its use should not be recommended, but where it is used special attention should be paid to keep it clean and in working order.

The custom of draining from one story to the next story below by the use of an open down spout should not be permitted. The drainpipe should extend from the sewer in the lowest story up through the building to the highest fixture and from there should extend above the roof. Each separate story should be connected through a trapped

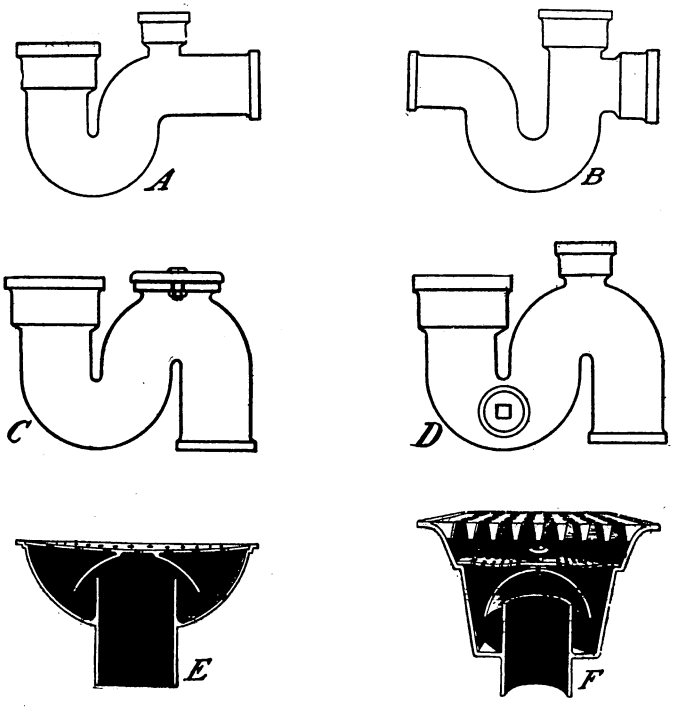


FIG. 6.—Types of traps for drainage in abattoirs. *A*, "P" trap with vent; *B*, running trap with vent; *C*, "S" trap with hand hole and cover; *D*, "S" trap with vent and brass trap screw on side; *E*, section of bell trap; *F*, section of cesspool bell trap.

pipe to the main vertical drainpipe. If S, half S, or P traps are used, the traps should be vented from the crown of the trap, and the vent pipe must be carried up through the building and through the roof.

When the floor drainage is emptied into catch basins instead of directly into the sewer the lowest end of the drain should be entirely submerged in water, so as to make a water seal to prevent the gases of the catch basin from permeating the various rooms by way of the drain. Catch basins and skimming tanks should be located entirely outside of any rooms where meat food products are prepared, handled, or stored.

The size of the drainpipes should not be too large nor too small, but of a size that will be completely flushed. All down spouts or conductors should be of cast iron or wrought iron and made continuous from the top story to the bottom, where they should be connected to the sewer pipe. All joints of the pipes should be made air and water tight. In the refrigerated rooms containing cooling pipes there should be supplied proper gutters below the pipes to receive the ice and water formed by condensation and subsequent thawing. The down spouts from the drip pans of the refrigerator coils should have cast-iron or wrought-iron sections at the lowest end of conductors so as to prevent the jamming and closing of the outlet. It has been the custom to make these down spouts of galvanized iron, and where they have not been protected by boxing the trucks have jammed the ends of the conductors so that they have become not only worthless as conductors but a source from which the air of the rooms has been fouled.

Every plumbing fixture should be separately trapped by a water-sealed trap placed as close to the fixture as possible, and if located within the building, vented, except in the case of the upper or only water-closet on a soil pipe extended full size through the roof, the closet having the center within 2 feet of the center of the stack, in which case no vent is required. Where three or more water-closets discharge immediately into a horizontal branch and thence into a vertical soil-pipe line carried through the roof as a vent, the vent may be omitted and an extension of the branch line substituted not less than 3 inches in diameter, to be reconnected to the main vent or carried through the roof independently.

A floor trap for a shower should be vented unless located in a cellar the paving of which renders the trap inaccessible. Every vent should be taken from the crown of the fixture trap except the water-closet trap. Each vent pipe should run independently above its fixture in order to prevent its use as a waste. Each vent may be connected above the highest fixture into the adjacent soil pipe if distant therefrom not more than 6 feet. If more than this distance from the soil pipe the vent must be independently extended above the roof. Main vent risers having a length of 15 feet or more should be connected at the foot into a main waste or soil line below the lowest vent outlet and with no greater angle or connection than 45 degrees.

The sinks in the lavatories should be of metal and prepared so as not to rust. Galvanized iron or enameled iron are most in use. The enameled iron is the more easily kept clean but is less durable. The waste pipes from sinks in the working rooms should be connected to the sewer system. The practice of allowing the waste water to run onto the floor should not be permitted. The waste pipe should be trapped immediately below the inlet and the trap should be furnished

with a vent pipe which is to be extended into a common vent system up to the highest fixture. Above the highest fixture the vent pipe may be connected to the soil or drain pipe and the pipe extended above the roof.

VENTILATION.

By the term "ventilation" is understood the continuous introduction of pure air into a room or building in such a way as to mix it thoroughly with the air contained therein, and the simultaneous removal of a like quantity of the impure air. The ventilation of rooms and buildings is necessary in order to prevent the accumulation of the impurities of respiration, combustion, and putrefaction.

It is extremely difficult to give any definite rule for the amount of cubic space required, or for the rate of the change of air. It is obvious that in a small room containing many persons the air should be changed much oftener than in a large room containing but a few persons. In factories it may be stated that in general from 2,000 to 3,500 cubic feet per hour per person is required for good ventilation. This will allow only for a change of air twice an hour when each person has from 1,000 to 1,800 cubic feet. Where this cubic space per person is less the rate of change of air should be greater.

The incoming air must not have such a velocity as to make itself felt to any marked degree. The inlet openings should not be large and should be so placed that the current of incoming air does not immediately find its way to the exit or exhaust openings.

The quality of the incoming air is of equal importance with the quantity. Care should therefore be taken that the source from which the air supply is drawn shall be as free from impurities as possible. In some instances it will be necessary to wash or filter the air before it is introduced into the building.

The current of incoming air should be imperceptible, especially when, as is generally the case, the outside air is lower in temperature than that of the room to be ventilated. A current of air not to exceed 3 feet a second will generally be found to be unobjectionable, as the draft will be very slight. If the currents are entirely above the persons much greater speed may be maintained; the larger the areas of the inlet and the outlet openings the slower the velocity of the air current.

The fresh air must not only be supplied; it must also be diffused equally throughout the space so as not to pass directly from the point of entrance to the point of exit. Special attention should be paid to this matter, otherwise there will not be the proper displacement and renewal of the vitiated air.

Ventilation is effected either by natural means or by the aid of mechanical equipment. The former is called natural ventilation and the latter artificial ventilation.

NATURAL VENTILATION.

In all buildings there is a very slow interchange between the inside and outside air by diffusion through the substance of the walls and floors themselves. This diffusion takes place through almost all the substances used in building construction. The more porous the material the more rapid the diffusion, the diffusion being caused by unequal pressure. Because of the slowness with which this diffusion takes place it becomes necessary to provide additional means to supply the needed amount of fresh air. Thus openings in the walls, such as doors and windows, or special openings into ventilating shafts are employed.

The natural ventilation through the pores of the walls is but of little moment generally, but an unequal temperature in two adjacent rooms will cause the air of the rooms to equalize, so that it is necessary, if the air of adjoining rooms is to be kept separate, to make the dividing partitions, floors, and ceilings air-tight. This point is well illustrated by the construction of chill rooms. The partition, floor, and ceiling in these rooms are "insulated," which is only a method to reduce to a minimum the diffusion of the air.

When only natural ventilation is employed the action of the wind is depended upon to give the required ventilation. Open windows and doors allow the entrance of moving masses of air. When the openings are sufficient in number and properly placed this method gives acceptable results; but when the outside air becomes cold, as in winter, the windows are closed more or less and in consequence the rooms do not get the necessary ventilation. Another objection to the system of natural ventilation is that the air admitted in some instances is fully as foul as the air in the room, so that practically no ventilation takes place. The admitted air may be cooler, but not of better quality. When the carbon dioxid does not exceed 6 or 7 parts in 10,000 the air is good, and any system that will keep it down to this may be called good. But in order that the carbon dioxid may be kept as low as 6 or 7 parts by volume in 10,000 parts, it will usually be found necessary to install a system of artificial ventilation.

ARTIFICIAL VENTILATION.

Artificial ventilation is that form of ventilation in which the movement of air is produced by artificial contrivances. These may be of two kinds—heat and mechanical—and either of these may be arranged for extraction of the foul or vitiated air or propulsion of fresh air. The former is sometimes called the vacuum and the latter the plenum system.

In practice, heat is employed only as a means of ventilation by extraction, not by propulsion. The most common method is to intro-

duce coils of hot water or steam pipes or gas burners in a ventilating shaft. Whatever the source of the heat, it is best to place it at the bottom of the shaft and not at the top, except when it is desired to extract the steam from a room through a vertical flue constructed of metal. In this case if the heating pipes are placed near the top they will warm the metal of the flue, thus preventing to a great extent the condensation of the steam. The great disadvantage of extraction by heat is its irregularity of action, as it is almost impossible to regulate the temperature of the column of heated air; consequently the upward current will sometimes be far more rapid than at other times. It is also expensive to maintain on a large scale.

The mechanical means used are chiefly fans. The fans are almost always rotary, and may be either centrifugal or axial. Axial fans are more suitable where a large volume at low pressure and velocity is required; centrifugal fans are better for the production of high velocity and high pressure. It should be noted, however, that a large fan worked at low pressure is more economical than a small one at high speed. The blades are best curved in centrifugal fans, and flat and inclined in axial fans.

Fans can be used either for extraction or propulsion, and may derive their motive power from engines or electric motors. The amount of air delivered can be calculated by taking the velocity of revolution of the extremities of the fan; three-fourths of this equals the velocity of the air, this allowance being necessary on account of friction. The sectional area of the conduit being known, the delivery per second can be calculated from these data.

Certain points require attention in all arrangements for artificial or mechanical ventilation:

1. The point of intake for the fresh air must be selected at such a location as will insure the air being pure, and, as a general rule, the purest air will be found at a height of 10 to 15 feet above the ground, unless influenced by local conditions such as the close proximity to slush boxes, fertilizer buildings, stables, cattle yards or pens, air vents of sewer, or similar conditions.

2. In the last-mentioned cases the air would require cleansing or filtering. This may be done by means of screens of coarse cloth or cotton, and the air may then be washed by passing it through a spray or through a wire screen over which a fine stream of water is running. This adds moisture to the air, and if it is to be forced into chill rooms it will require drying.

3. The temperature of the incoming air should be under control. It may be chilled by passing over and through refrigerating coils, or it may be heated by passing across steam coils.

4. The channels through which the air is conducted must be so arranged as to be easily cleansed. This is especially necessary in the propulsion method. Extraction shafts also require to be kept clean.

The extraction method is less costly than the propulsion method, but it has the disadvantage of not having the source of the incoming air under control, and consequently impure air may be admitted. In the propulsion method the inlets are entirely under control if properly arranged, and the purity of the air can be assured. A proper diffusion throughout the room is more easily effected as well. It is sometimes an advantage to combine the two methods.

EQUIPMENT.

All the equipment should be of a sanitary character. Stone, metal, and glass are three of the best materials to be used. Wood is acceptable only when in perfect condition. Wood when subjected to alternate treatments of wetting and drying soon becomes altered in condition and is subject to decay.

All machinery, tables, benches, and other equipment should be so constructed and located that all the parts may be readily cleaned.

TABLES.

Table tops of wood should be covered with metal. For this purpose iron heavily coated with tin is perhaps as lasting as any metal. Zinc is too soft and soon becomes filled with dents and holes, and as metallic zinc is soluble in the acids occurring normally in meats and meat products, zinc and galvanized metal should not be used where they come in contact with these products intended for food. Holes in metal tops should be immediately repaired. Wooden tables and trucks with cracks and with the wood splintered should not be used. Tables should not be fastened against walls or partitions unless the metal covering of the table is continued and carried up on the walls. The covering should be carried up on the walls to such a height that there is no possibility of meat shreds, chips, or pieces becoming lodged between the lining and the wall to which it is fastened. When the tables or benches are not covered they should be so constructed as to be removable from against the wall to facilitate cleaning. Tables of glass are satisfactory only so long as they are in perfect condition. Glass readily cracks through uneven strains caused by unequal expansion or contraction. The perfect table is made of a particularly hard nonabsorbent soapstone. Tables of cement manufacture are in use, but if the cement is not made nonabsorbent they are not sanitary. The frames and legs are preferably constructed of metal.

TRUCKS.

Trucks at the present time are made of wood, wood bodies lined with sheet metal, metal bodies, and cast-iron enameled bodies. The enameled iron trucks have not proved successful, as they are exceed-

ingly heavy and the enameling does not stand rough handling. If the enamel is of the gray or blue variety it will be found more serviceable than the white. The trucks made of wood are satisfactory only when they can be kept clean. The process of cleaning by hand is not satisfactory. The best method to clean trucks is by immersion in a tank containing the cleansing fluid. By this method every part of the truck is reached, which result is not obtained when an attempt is made to clean by the use of brushes. When the truck body is made of sheet metal in such a manner that the inside surfaces are perfectly plain, the cleansing of the truck can be done by hand satisfactorily. Some of the sheet-metal trucks are so made that the reenforcing angles are placed in the inside corners, making the inside surfaces of the trucks uneven and difficult to clean. The angle reenforcement may be placed on the outside of the corners without decreasing the strength of the truck, and if the metal edge be soldered there will be no cracks or crevices to retain dirt, and the truck can therefore be more easily cleaned.

CONVEYORS.

Conveyors are of various kinds, the bucket and belt pattern being the most extensively used. From a sanitary standpoint neither kind is to be recommended, as the machines can not be kept clean.

CHUTES.

Long metal chutes should be so constructed that the inside of the chute will be as nearly free from unevenness as it is possible to make it. The overlapping joints should be so made that the upper sheets will overlay the lower sheets. Chutes are made preferably of cast iron heavily coated on the inside with block tin, or coated with porcelain enamel. Porcelain-enamel lined cast-iron pipes up to 15 inches inside diameter are now on the market. These pipes should have the joints made with litharge and glycerin cement. This cement is acid and waterproof and withstands well the expansion and contraction of the pipes. All chutes should have numerous hand holes to facilitate cleaning.

LAUNDRY.

A properly equipped laundry should be furnished, in order that the employees may be supplied with clean outer clothing.

PROTECTION FROM RATS, FLIES, AND OTHER VERMIN.

Since rats, flies, and other vermin are sources of filth and frequently transmit disease, they should be rigidly excluded from all compartments containing meat or meat food products. Besides the objections mentioned, extensive pecuniary losses are caused by the depredation of rats.

Rat-proof construction should be employed in building new abattoirs and packing houses. Much can be done by changes in existing houses toward getting rid of and keeping out rats. As is generally known, rats will burrow in the walls and floors of packing houses, and they are usually found in large numbers beneath the floors of cattle pens, alleyways, sheds, and platforms, especially if the floors of these are of wood laid directly on the ground. Wherever possible wooden floors should be replaced by brick or block pavements laid on cement, or by concrete construction. Platforms should be built open in front and paved below. The walls of chill rooms, both outer and inner, should be of rat-proof material, and the space between the walls should be guarded against rats by wire screens at the top and at each floor. All sewer openings, air flues, and windows through which rats might enter should be screened.

During the fly season all doors and windows should be fitted with efficient fly screens.

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